Benefits and limitations of implementing Chronic Care Model (CCM) in primary care programs: A systematic review

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Highlights

- This systematic review analysed Chronic Care Models for cardiovascular diseases.
- Most studies reported outcome improvements and patient compliance with treatment.
- Some studies demonstrated reduction of medical burden, like healthcare utilization.
- They are effective to reduce risk of heart failure & other cardiovascular diseases.
- They are restricted by academic robustness and social constraints in primary care.

Abstract

Background: Chronic Care Model (CCM) has been developed to improve patients' health care by restructuring health systems in a multidimensional manner. This systematic review aims to summarize and analyse programs specifically designed and conducted for the fulfilment of multiple CCM components. We have focused on programs targeting diabetes mellitus, hypertension and cardiovascular disease.

Method and results: This review was based on a comprehensive literature search of articles in the PubMed database that reported clinical outcomes. We included a total of 25 eligible articles. Evidence of improvement in medical outcomes and the compliance of patients with medical treatment were reported in 18 and 14 studies, respectively. Two studies demonstrated a reduction of the medical burden in terms of health service utilization, and another two studies reported the effectiveness of the programs in reducing the risk of heart failure and other cardiovascular diseases. However, CCMs were still restricted by limited academic robustness and social constraints when they were implemented in primary care. Higher professional recognition, tighter system collaborations and increased financial support may be necessary to overcome the limitations of, and barriers to CCM implementation.

Conclusion: This review has identified the benefits of implementing CCM, and recommended suggestions for the future development of CCM.

Abbreviations

Abbreviations: ACIC: Assessment of Chronic Illness Care score; CCM: Chronic Care Model; CIS: clinical information systems; COPR: community-including organizations and resources for patients; DS: Decision Support; DSD: Delivery System Design, HSHO: Health System or a Health Organization; PACIC: Patient Assessment of Chronic Illness Care; SMS: self-management support

Keywords

Chronic Care Model; Diabetes mellitus; Hypertension; Cardiovascular disease; Chronic obstructive pulmonary disease

Introduction

Worldwide, chronic disease remains a significant burden in terms of morbidity and mortality. Diabetes mellitus (DM), hypertension (HT), cardiovascular disease (CVD) and chronic obstructive pulmonary disease (COPD) are four major chronic disease states with a high prevalence in populations around the world. The incidence of these four diseases has increased rapidly in recent decades [1–9]. Historical models of clinical care, largely developed for acute illness management, are proving less able to meet the complicated needs of the increasing burden of chronic care [10,11]. As a result, ineffective therapy and suboptimal disease control could lead to patient dissatisfaction [11]. Escalating healthcare demands have led to a substantial increase in medical burden, including avoidable hospital admissions and unnecessary healthcare expenditure [12,13].

Chronic Care Model (CCM), one of the widely recognized disease models in the world [14], was proposed by Wagner et al. in the 1990s [10]. It served as a patient-centred, evidence-based, proactive framework that aims to redesign ambulatory care systems and achieve health care improvement for patients suffering from chronic disease [10,14–16]. CCM consists of six key components, including health system or a health organization (HSHO), clinical information systems (CIS), decision support (DS), delivery system design (DSD), self-management support (SMS) and community-including organizations and resources for patients (CORP) [10,14,17]. Wagner [10] advised that the interactions between patients and healthcare providers should consist of well-developed processes and incentives that allow changes in the care delivery system. Additionally, these CCMs could give behaviourally complicated self-management support that offers priority to enhancing patients' confidence and skills, so that patients can be the ultimate manager of their own illnesses. Also as Wagner defined [10], the CCMs could “reorganize team function and practice systems; develop and implement evidence-based guidelines and support those guidelines through provider education, reminders, and increased interaction between generalists and specialists; as well as enhance information systems to facilitate the development of disease registries, tracking system, and reminders and to give feedback on performance.”

So far, CCM has been adopted and implemented in many areas of medical practice [10,12,18–24]. The results of these studies have suggested that implementation of CCM could greatly improve medical outcomes and reduce unnecessary medical burden. Strategies for preventing avoidable hospitalizations suggested by articles in the literature are strongly connected with CCM components, such as self-management training for both patients and healthcare providers

[12,21,22,25,26], identification of existing community resources [12,27,28], electronic systems of medical records for monitoring, as well as sharing and linking among ambulatory services, hospitals and communities, and primary care practices [12,13,29]. Moreover, healthcare providers have shown good adherence to the medical practices which were tailored and multifaceted with CCM components [30]. Nevertheless, no single component within CCM may achieve all these expected goals, indicating that adopting multiple components of CCMs is essential to enhancing quality health in primary care [10–12,14–16,19,31–34].

This review aims to summarize and analyse the primary care programs specifically designed and conducted for patient care that comprise various CCM components. The papers reviewed here present a clear view of the current development of CCM implementation in primary care. The medical and social benefits to patients and healthcare providers, as well as present limitations in the system have been systematically analysed and discussed. The objective of this review is to identify the benefits and limitations of CCM so as to inform future optimization of CCM for chronic disease care.

Methods

The present systematic review included models of chronic disease care, including diabetes, hypertension, cardiovascular disease and chronic obstructive pulmonary disease. Since both PubMed and EMBase cover the literature of Medline and PubMed alone has the features of easy keyword searching and automatic mapping to MeSH terms without the need of subheading selection, we chose PubMed as convenient and applicable for our use. Thus, the search was performed in the PubMed database from its inception (literature covered back to 1966) to June 2016 by using the following strategies:

1. Model*[Text Word] AND chronic care [Text Word] (1050 articles identified)
2. Limit 1 to “Humans” (824 articles identified)
3. Limit 2 to “English” (789 articles identified)
4. Limit 3 to “full text” (702 articles identified)
5. Limit 4 to each of following sub-theme by combining with the search terms shown in strategy 1

a. Diabetes[Text Word]

b. Hypertension[Text Word]
c. Cardiovascular disease[Text Word]
d. Chronic obstructive pulmonary disease[Text Word]

The articles included were those that described models providing proactive care for patients with diabetes, cardiovascular disease, hypertension and/or chronic obstructive pulmonary disease. The papers identified focused on clinical perspectives of the models, defined as the direct observation of patients or the viewpoint of health professionals, such as doctors and nurses who worked directly with patients. Articles were excluded if they were duplicate, or did not involve any observation on patients. Meta-analyses, reviews, protocols and commentaries were also excluded. An extensive literature search and careful screening of the potentially eligible studies included in this literature review were performed by two independent reviewers, and any disagreement was resolved by a third reviewer. Supplementary Fig. 1 shows the algorithms by which the articles were included.

Results

A total of 702 journal articles were retrieved based on the first three steps of the search strategy. Of these articles, 308 were obtained under the four disease categories. After reviewing the titles and abstracts, 278 were excluded. Five duplicates were removed, resulting in a total of 25 articles being included in the present review (Table 1). All these reviews were related to four chronic medical conditions (i.e., diabetes mellitus, hypertension, cardiovascular disease and chronic obstructive pulmonary disease).

1. Diabetes Mellitus

Among all the 25 selected articles, 23 were published in the period 2002–2015 on patients suffering from diabetes as the primary study focus. They demonstrated the impact of CCM on primary care (Table 1). One of these articles by Bodenheimer et al. [17] summarized three CCM-introduced programs in diabetes patients. Hence, there were 25 individual studies included in this review. Based on the information provided in the articles, the majority of the enrolled programs (19/25) were led by professional healthcare providers (i.e., physicians, physician/medical assistants, residents, primary care clinicians, registered nurses, nurse assistants, and health workers) in at least one hospital or primary care centre. The number of participating patients varied from 68 to 553,556 due to the different scales among the included studies. Most programs recruited older patients as

subjects and one-third of these studies focused on type 2 diabetes patients. One of the programs included patients with cardiovascular diseases as a comorbidity. Different types of intervention-related studies were used to investigate the impact of CCM implementation. The follow-up period varied between 3 months and 4 years.

A total of 19 enrolled programs (Table 2) reported clinical outcomes that illustrated the impact of CCM implementation on disease optimization. There were several important medical indicators measured in these programs, including HbA1c (Glycated Haemoglobin), blood pressure (in particular systolic blood pressure, SBP), blood lipid levels (e.g. low-density lipoprotein cholesterol), body mass index (or weight), foot examination and periodic eye examination. These data were reported by two different methods: the proportion of patients who reached optimal clinical targets (e.g. HbA1c $\leqslant$ 7%, BP $\leqslant$ 130/80 mmHg or LDL < 100 mg/dl) and the average value of the clinical indicators. Based on a pooled analysis, the proportions of patients reaching the targets in HbA1c, blood pressure and blood lipids in the intervention group were 1.8–28%, 3.8–45% and 3.2–58%, respectively, which were higher than those in the respective control groups. Among them, three programs found significant differences in the improvement of HbA1c, and two programs reported improvement of blood pressure and blood lipids, respectively. Similar significant improvements in these clinical parameters were found when the average values of the intervention and control groups were compared.

In addition, the implementation of CCM was found to bring benefits in patient compliance with therapy, promotion of health behaviour, satisfaction with clinical care, and reductions in the medical burden (Table 3). Data from intervention groups showed an average of 15% improvement in the rate of measuring HbA1c, blood pressure and blood lipids. Also, more obvious improvements were observed in terms of health behaviours (compared with control groups, additional improvement in intervention groups 5.6–85%, average ~ 30%), including the rate of BMI measurement, smoking status assessment, foot examination, eye examination and self-management plans formulated by healthcare professionals. In six of these programs, both Assessment of Chronic Illness Care (ACIC) score and Patient Assessment of Chronic Illness Care (PACIC) score increased, indicating that patients were more satisfied with CCM implementation compared to usual care. Furthermore, there were two programs that reported the cost-saving aspects of the CCMs. Stock [35] indicated that the Germany Program saved 446.75 USD in the overall cost of illness care per insured patient during 2003 to 2007 and shortened the hospitalization duration per insured patient by 1.44 days. Siminerio [22] reported an 80,000 USD increase in net revenue of “Diabetes Self-Management Training”

reimbursement and educators' salary from Jan 2002 to Jun 2004. On the other hand, Vargas [36] measured the 10-year cardiovascular risk for the diabetes patients and found a reduced risk at 2.1% in the group that received interventions under CCM.

2. Hypertension (HT), Cardiovascular Disease (CVD) and Chronic obstructive pulmonary disease (COPD)

Among the 25 enrolled programs, there were three programs focusing on HT, four programs on CVD and one program on COPD. Stroebel [37] and Chen [38] included hypertensive patients, whereas Turner [39] conducted a single blinded RCT among African-American patients with uncontrolled hypertension. Caruso [40] recruited patients with CVD only and patients with CVD and DM as a comorbidity; Vargas [36] studied the impact of CCM implementation on reducing 10-year CVD risk among DM patients; Lalonde [41] carried out a one-day workshop (six focus groups) for CVD-risk patients, family members, physicians, other professionals, decision makers and researchers, in which the opinions on CCM implementation were discussed. Mirzaei [42] performed a focus group study among 52 COPD/CHF/DM patients, 14 patients' care-givers and 63 health care professionals with respect to their concerns and suggestions on CCM.

Among these studies, there are six programs with a number of participating patients ranging from 109 to 1,170 [36–40]. After 6 months to one year, the outcomes obtained from the follow-up of these programs showed that the proportion of patients who reached clinical targets greatly increased. In particular, individuals in the CCM intervention group (Turner et al., [39]) had greater reductions in the average systolic or diastolic blood pressure values. Other medical outcomes showed similar findings.

Furthermore, two qualitative studies reported the opinions of healthcare providers and patients in more depth. In Mirzaei [42], patients, their care-givers and health care professionals discussed the challenges, suggestions and solutions regarding [1] communication and delivery of information; [2] organization of service delivery and waiting time to see HCPs; and [3] facilitation of self-care, focus on a single illness, and inclusion of patients and their care-givers in decision making. Lalonde [41] suggested eight proposals for relevant CCM components, and the top three priorities included the desirable need of “a computerised platform assessable to all health providers”, “a multidisciplinary team”, and “a case management nurse position.”

3. CCM components

Generally, the implementation of Chronic Care Model had made significant improvements in primary care. All the enrolled programs contained at least three components of CCM (six components in total), as shown in Table 4. The CCM components have been adopted in ~ 76% of enrolled programs on average. Among the six components, Self-Management Support is the most popular (96.3%) and Community including Organizations and Resources for Patients (CORP) is the least popular (40.7%). These programs consist of a variety of components that were designed according to the requirements of the CCM components [10] (Table 1): (a) Team building, health provider group meeting and feedback were the most frequently conducted activities according to the concept of "Health System or a Health Organization" (HSHO) component; (b) Electronic record or registry was required by "Clinical Information Systems" component (CIS); (c) Provider education, guideline or protocol development and distribution were typical activities involved for "Decision Support" (DS) component; (d) Electronic alert or phone call reminder to physician or patients, visits in follow up, and scheduled appointments or meetings were widely held for "delivery system design" (DSD) component; (e) Patient education and self-management/care plan helped in patient motivation and behaviour change, which were to achieve the objective of "Self-management Support" (SMS) component; and (f) Specialists or expert participation, and community clinician involvement were used to strengthen the "Community including Organizations and Resources for Patients" (CORP) component.

4. Unique contributions of CCM components to patient care

The "Health System or a Health Organization" (HSHO) component

The functions of HSHO and its connections with other health service providers form the basis of the rest of the Chronic Care Model components [17]. The environment of a HSHO, ranging from local policies of the community to national policies of the government, exerts a great influence on chronic care management [31]. HSHO of health care could be enhanced to reward quality and sustain the improvements of chronic care by featuring innovation and favourable funding [41] The introduction of innovative leader to HSHO could also incentivise chronic care planning [47].

The "Clinical Information Systems" (CIS) component

CIS tracks patients seeking chronic care at different levels: from primary to secondary and tertiary [31]. It contributes to patient care in three ways, 1) by acting as a registry system for managing health service of a population; 2) by providing reminders that keep primary care physicians (PCP) in compliance with clinical guidelines; and 3) by providing feedback to control quality of care [17]. Registry produces database that offers longitudinal information at an individual level and its

establishment enable patient outreach and visits planning [43,20]. Sharing electronic medical records (EMRs) also facilitate inter-professional and inter-institutional communication for patient care [40].

The "Decision Support" (DS) component

DS for PCPs includes education and training as required to enable enhanced communication and counselling skills among PCPs; their compliance with guidelines; as well as quality control and surveillance of health service [31]. Evidence-based guideline is an important decision-support modality that provides recommendations, on which PCPs feedback information and reminder systems of CIS are based [17]. Involvement of specialists in primary care is another decision-support tool. In planning specialist referrals, PCPs could decide conventional referrals or simply a phone consultation that does not always need conventional referral [20].

The "delivery system design" (DSD) component

An important way to promote DSD is to strengthen roles of manpower in delivering primary care, and to enable referral to specialist for consultation and treatment where appropriate [47]. Primary care centres with sufficient PCPs, active specialists, and follow-ups for patients provide more opportunity for health management and contribute to better chronic disease control [31]. A multidisciplinary health centre characterised with availability of inter-professional collaboration would also benefit patients in maintaining their continuity of care [41].

The "Self-management Support" (SMS) component

SMS, based on patient empowerment, is a key function of the Chronic Care Models [17]. It is developed and supported by education, counselling, and training of patients with non-communicable disease and their families with lifelong follow-up and self-assessment of care [43]. Patients with relevant knowledge and skills are able to manage the chronic conditions by themselves. Besides, several studies show that SMS can contribute to improved clinical outcomes, better quality of life, and decreased costs [49]. Development of SMS requires both patients and the health providers to share responsibility for continuous improvement of patient care [44].

The "Community including Organizations and Resources for Patients" (CORP) component

CORP involves proper allocation of available community resources and promotion of national and local governmental policies to create a chronic disease care-friendly environment [31]. To promote high quality chronic care, health providers need linkages with community-based resources which

are especially useful for small care centres with insufficient resources [17,24]. Community resources may help patients acquire self-management skills, such as achieving lifestyle modifications that positively influence chronic disease control [40]. It could be incorporated in daily clinical consultations as easy-to-access resources that meet patient needs [41].

Acknowledged limitations

Except the three case studies reported by Bodenheimer in 2002, the majority of the literature acknowledged several limitations in their programs. These include weaknesses in study designs, data contamination and constraints, biases caused by selection and system, problems associated with differing characteristics of patients and professional providers, methodological issues of intervention and follow-up, as well as pressures induced by budgetary constraints. Because CCM implementation played a very important role in the selection of patients and intervention of the enrolled programs, more concerns were raised than other program terms, which made these two the most frequently mentioned limitations (11/25 and 12/25, respectively) in the analysis. Data contamination and follow-up issues are the least frequently reported limitations (both at 4/25) among the analysed programs. The literature also mentioned that professional providers (e.g. health coaches, centres and residents) are the most significant source of contamination. Other limitations of these CCM were mentioned in 5/25 to 9/25 of the programs.

Discussion

Diabetes mellitus, hypertension, cardiovascular disease and chronic obstructive pulmonary disease are four major chronic diseases in terms of medical burden on a global scale. A close relationship among these four major chronic diseases is well recognized; and high blood sugar, plasma lipid and uncontrolled blood pressure levels are common clinical indicators. These chronic diseases are significantly associated with unhealthy lifestyles (e.g. dietary intake of high-glucose/fat, lack of physical activities, tobacco use or alcohol consumption). Thus far, attempts to design and implement CCMs have been realized in primary care programs for several decades. As shown in Supplementary Fig. 2 and Table 1, six CCM components operate and interact in a multidimensional manner [37,39,43,44]. Increasing the number of CCM dimensions has been shown to produce more benefits to patients and healthcare providers, considering [1] patients may receive improved medical outcomes, more knowledge about disease management and enhanced health awareness; [2]

health professionals may obtain training in working in the teams comprised of multiple types of co-workers; and [3] social medical burden may be reduced due to effective disease management and reduced disease risk in the population.

There were also several limitations and barriers to CCM implementation in the included studies, such as the robustness of academic evaluation and societal factors (Supplementary Fig. 2, Table 4). Among all the studies included in this review, six programs stated the absence of blinding or randomization [20,35,37,40,43,44]; four programs reported that the follow-up period was too short for the adequate detection of significant outcomes [24,38,45,46]; whilst three programs had a relatively small sample size [21,28,47]. Selection bias in patient recruitment includes differences in illness status [35], racial and cultural diversity [36,37,48], as well as in socioeconomic status [35]. As a result, the study findings might not be generalizable to other population groups [42]. In addition, non-medical practical issues also play an important role in CCM implementation. Most of the programmes were based on efforts made by volunteering healthcare providers. Therefore, some healthcare professionals might not join the programme or simply drop out, and in some programmes the relevant stakeholders might have lower motivation [36,39]. Sunaert et al. [24] mentioned that some physicians expressed their fear of losing patients and practice income because they thought that the primary care programmes could not receive enough attention and might not be appropriate for certain patients. Working in relatively isolated environments with lack of support in practice has been recognized as a barrier, especially in primary care systems that were not efficiently organised [24]. There are various social determinants of health and a CCM might not be able to address all components especially in populations with different patient groups. Hence, for CCM to function optimally, policy-makers will need to take into account various factors related to system design, including different socioeconomic factors, accessibility to healthcare, and the technology available. Moreover, it is occasionally difficult to motivate patients when consultation times are limited [24]. Furthermore, implementation of CCM in the community requires multidisciplinary team collaboration in an organized, concerted manner, and this might not be easily achievable in countries where primary care is still developing. Finally, existing studies have not demonstrated that CCM could account for all the beneficial effects per se, since patients are treated and managed in an individualized manner.

Thus far, there are several studies examining CCM using different perspectives, such as a comparison of CCM with other primary care models [14], perceptions of CCM implementation among relevant stakeholders in primary care settings [33], or CCM implementation in a certain

disease management [11,23]. However, there exist knowledge gaps regarding the consistent benefits and limitations during CCM implementation in different programs/interventions reported by the existing literature. The strength of this review includes its comprehensiveness in extracting the important constructs of CCM, offering deeper insights into CCM implementation contextualized to the current medical system, and delivering important message to policy makers or stakeholders for future improvement of chronic disease management.

Unique contributions of CCM components to patient care

Among the included studies of this review, some (8/25; 32%) have attempted to separately investigate individual components of CCM while others implemented the entire CCM as a multifaceted intervention. The results gave us an overall impression that CIS, DSD, and SMS were priorities when implementing CCM in the primary care settings.

Deviation in CCM practice scores across sites was identified for CIS and HSHO in a study [50]. Variation of the implementation improvements was also found for different components by using Assessment of Chronic Illness Care survey (ACIC). Sunaert et al. discovered in their program the scores of all components increased with those for DSD and CIS changed the least [24]. Although their project was then expanded, it had only a limited impact on the CCM at the primary care level (DSD) and the use of CIS in practice. Another study had similar findings that the sub-scales except for DSD demonstrated significant improvements in post-implementation ratings [31]. However, the program led by Frei et al. found statistically significant differences in changes over time between intervention and control group patients in all CCM components, yet did not find statistically significant differences in changes between different components over time [45].

Additionally, there was variation in the use of components with better results. Yu et al. identified two interventions, the registry in CIS and patient skills in SMS, had the greatest influence on improving incorporation of the CCM [47]. Musacchio et al. concluded the DSD and SMS were systematically associated with better process and outcome measures [49], whereas another study by Lalonde et al. regarded CIS and DSD as the priorities selected for prevention in Primary care [41].

Although these studies tried to explain the results in relation to the various CCM components, evaluation of CCM is challenging given the fact that these components may act both independently

and interdependently. Within a program, variation in CCM practice scores for each component across sites may result in that performance cannot be meaningfully compared between practices. The decentralized operating units may have also caused variability in the way domains of the CCM are implemented and in the relative emphasis on each domain. Implementation varies between study sites and for individual domains within sites; as a result, local population care programs differ across the system. However, given the relatively low marginal cost per patient of providing the entire collection of services, the effectiveness of individual CCM components might not be of substantial significance.

Limitations

Some limitations of this review should be addressed. The literature was retrieved based on search strategies in PubMed, by which only the references that specifically mention Chronic Care Models were included for discussion. Therefore, the number of the studies that could be reviewed might be limited. Studies that were published in language other than English were not included, and there might be a certain number of articles published in the grey literature. Besides, these studies have been mainly conducted in the developed countries. The conclusion may not be generalizable to other regions due to the variation in age, income, access to care, available technology and other social and demographic characteristics. Especially for developing countries experiencing an epidemiological transition, Chronic Care Models need to be further examined in future studies.

Conclusions

According to the present systematic review, the implementation of CCM in primary care can substantially improve medical outcomes, enhance patients' quality of life, and decompress social burden in a multidimensional manner. Nevertheless, there are some limitations of CCM that might need to be carefully scrutinized, such as health professionals working in isolation, who may have low motivation, economic concerns and insufficient knowledge; patients who are difficult to motivate; errors and omissions present in clinical information systems; as well as limits of linking with the community etc. These implied that greater collaborative efforts from various stakeholders in the society and additional financial support may be required. Further optimization and integrative applications of the six CCM components, as well as the empowerment of their interactions, may bring benefits to the health care system.

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Table 1. Characteristics of studies included in the present review

Author	Publish year	Study design	Patients types*	No. of Professional Facilities			No. of participating patients	Mean age [years] (male %)		Follow-up (years)
				Hospital or Primary Care Center	Physician or Related	Nurse or Technician or Related		Intervention	Control	
Page et al. [44]	2015	Pre- and post- intervention study	DM	NA	NA	NA	5539	50-59 (45.94[a])	50-60 (NA)	1
Ku et al. [31]	2015	Pre- and post- intervention study	T2	NA	NA	NA	164	56.76[a] (25.6)	NA (NA)	1.83
Frei et al. [45]	2014	CCT	T2	NA	30	NA	328	50 (54)	51.5 (60)	1
Hariharan et al. [20]	2014	non-RCT	DM	1	11 physician 32 residents 6 medical assistants	4	1674	57.8 (39.3)	57 (43.8)	1
Mirzaei et al. [42]	2013	Qualitative study	DM, CHF, COPD	2	63 residents	NA	52	45-85 (53.8)	NA (NA)	NA
Turner et al. [39]	2012	Single-blinded RCT	Uncontrolled HT	2	A peer and practice team	team	280	61.2 (30)	62.6 (39)	0.5
Lalonde et al. [41]	2012	Qualitative study	Potential CVD	NA	6 physicians	6 nurses	6 patients	NA	NA	1-day
					6 pharmacists	6 other health professionals 6 health administrators 6 researchers	6 family members			workshop
Musacchio et al. [49]	2011	Pre- and post-intervention study	T2	1	NA	NA	1004	66.6 (54.1)	NA (NA)	0.5-2
Chen et al. [38]	2010	non-RCT	T2 and HT	1	13 year-one residents	11 healthy workers	541	62.4 (37)	60.3 (36)	1
Barceló et al. [18]	2010	CCT	DM	10	43 teams		307	40-59[b] (NA)	40-59[b] (NA)	1.5
Yu et al. [47]	2010	Pre- and post- intervention study	DM	University-based	6 residents 2 faculty clinician or staff	NA	Small Size	NA (NA)	NA (NA)	1
Frølich et al. [50]	2010	Cross-sectional & stepwise regression	DM	41	NA	NA	553556	50 to >65[b] (51)	NA (NA)	NA
Khan et al. [46]	2010	Prospective single cohort study	DM	1	NA	NA	1098	51 (59)	NA (NA)	0.16–1
Sunaert et al. [51]	2010	Region-RCT	T2	41	83	90	4174	41.32 (47.13)	40.63 (44.31)	4
Stock et al [35].	2010	Pre- and post-intervention study	T2	NA	NA	NA	91696	NA (44.93)	NA (NA)	4
Sunaert et al. [24]	2009	Pre- and post-intervention study	T2	41	83	90	2300	NA (NA)	NA (NA)	4
DiPiero et al. [43]	2008	Retrospective cohort	DM	1	25 faculty members, 46 medical residents		565	58.9 (39)	58.3 (44)	0.5–2
Caruso et al. [40][c]	2007	Pre- and post- intervention study	T2, CVD and T2 +CVD	1	NA	NA	283	73.7 (32), 76.3 (37), 73.6 (30)	76 (36)	1
Vargas et al. [36]	2007	Controlled pre- and post-intervention study	CVD risk in DM patients	13	13	91	1170	64 (64)	65 (59)	1
Piatt et al. [28]	2006	Multiple-CCT	DM	11	21	3	68	69.7 (50)	68.6 (58.8)	1
Siminerio et al. [22]	2006	Pre- and post-intervention study	DM	166	1400	NA	31150	NA (NA)	NA (NA)	4
Siminerio et al. [21]	2005	non-RCT	T2	1	4 physician 1 physician assistant	3 registered nurses 2 technicians 1 nurse assistant	104	67 (64.7)	65.4 (42.5)	1
Stroebel et al. [37]	2004	Pre- and post- intervention study	DM, HT and HL	1	6 providers	2	109	NA (NA)	NA (NA)	1
MacLean et al. [48]	2004	Baseline of a CCT	DM	10 hospitals 55 primary care centers	121 medical providers		7345	>18 (NA)	NA (NA)	NA
Bodenheimer et al [17]	2002	Pre- and post- intervention study	DM	36 private office	100	NA	NA	NA (NA)	NA (NA)	NA
		Pre- and post- intervention study	DM	18	NA	NA	6542–7037	NA (NA)	NA (NA)	1
		Pre- and post- intervention study	DM	NA	NA	NA	NA	NA (NA)	NA (NA)	2

*Type: DM: diabetes mellitus; T2: type 2 diabetes mellitus; CHF: chronic heart failure; HF: heart failure; AT: arthritis, HT: hypertension; CVD: cardiovascular disease; HL: High Lipid.

a Number was calculated based on the information reported.

b Range of age is represented for the largest population in the study.

c This study included patients with T2 only, CVD only and T2+CVD, thus the data was listed in the same sequence.

Table 2. Clinical outcomes of the enrolled programs

Author (published year)	Program name	HbA1c[b]		Blood pressure (SBP)		Blood lipid			BMI (or weight)	Foot exam	Eye exam
		Difference of change (%)[a]	Mean change of value (%)	Difference of change (%)[a]	Mean change of value (mm g)	Difference of change (%)[a]	Mean change of value	Specific[d]	Mean change of value	Difference of change (%)[a]	Difference of change (%)[a]
Ku (2015) [31]	FiLDCare		− 0.8								
Frei (2014) [45]	CARAT		+ 0.1		− 3.6		-0.2	LDL (mmol/L)	− 0.4		
Hariharan (2014) [20]	DITTO		− 0.37								
Turner (2012) [39]	/				− 7.92						
Musacchio (2011) [49]	SINERGIA	+ 13.0		− 1.2		+ 7.6		LDL			
Chen (2010) [38]	Teamlet	+ 1.8		+ 3.8		+ 3.2		LDL			
Barceló (2010) [18]	VIDA	+ 4.5		+ 4.9		+ 6.9		C		+ 71.6	+ 61.8□
Yu (2010) [47]	SJOFMRP	+ 5.5		+ 22		+ 10		LDL			
Khan (2010) [46]	/		− 1.5		− 9		− 16	LDL (mmol/L)	(− 2.3 lb)		
Sunaert (2010) [51]	BE		+ 0.06				− 6.29	TC (mg/dl)			
DiPiero (2008) [43]	CIM	+ 17.5		+ 10		− 1		LDL			
Caruso (2007) [40]e	GAP		-0.6, NA, − 0.6				− 12.5, − 12.7, − 14.2	LDL (mg/dl)			
Vargas (2007) [36]	/		− 0.24		− 0.4		− 0.01	Log TC			
Piatt (2006) [28]	PTPROV		− 0.7		+ 2.7		+ 11.8	non-HDL (mg/dl)			
Siminerio (2006) [22]	DSMT		− 0.45								
Siminerio (2005) [21]	/	+ 15.4		+ 38		-30		LDL			
Stroebel (2004) [37]	/	+ 21 (n = 60)[c]		+ 45 (n = 89)[c]		+ 58 (n = 19)[c]		LDL			
Bodenheimer (2002) [17]	PHP	+ 28								Similar as HbA1c	
	HPMG	+ 7.8				+ 8.7		LDL			
	CC	+ 1.9									

a Difference of change (%): Proportion change of the patient number reached medical goal in intervention group (baseline vs. follow-up) – proportion change of the patient number reached medical goal in control group (baseline vs. follow-up).

b HbA1c: glycated haemoglobin.

c Because of different types of patients, the numbers of patients who participated in the test are addressed in brackets.

d LDL: low-density lipoprotein; TC: total cholesterol; C: cholesterol; HDL: high-density lipoprotein.

e This study included patients with T2 only, CVD only and T2 patients with CVD, so the data was listed in the same sequence.

□ Significant difference ($P < 0.05$).

Table 3. Changes of measurement rates (%) in terms of clinical processes, chronic disease scores, financial issues and other terms

Author (publish year)	Program name	Change of measurement rate % in clinical process (intervention group)								Overall ACIC score[c]	Overall PACIC score[d]	Financial issue		Other terms	
		HbA1c	BP (SBP)	LDL (or others)[a]	BMI	Smoking status assessed	Foot exam	Eye exam	Self-management plan made			Value	Specific	Value	Specific
Page [44]	FHQC	+ 2.4□□		− 0.1			+ 10.9□□	+ 5.6□□							
Ku [31]	FiLDCare										+ 0.3□□				
Frei [45]	CARAT										+ 0.2			No change	SF-36
Hariharan [20]	DITTO						+ 62								
Turner [39]	/													− 0.82%**	Predicted 4-year CHD risk
Chen [38]	Teamlet	+ 5.6		− 5.8□□	+ 85.0□□	+ 82.8□□			+ 36.8**						
Barceló [18]	VIDA				− 0.3					+ 3.0**					
Yu [47]	SJOFMRP					+ 9 (cessation)	+ 21	+ 20	+ 48	+ 3.64					
Sunaert [51]	BE	+ 3.71□□		+ 3.39□□ (TC)						+ 3.05					
Stock [35]	GP						+ 20.2	+ 10.9				− 446.75 USD	Overall cost difference[e]	− 1.44 days	Hospitalization per insured
Sunaert [24]	BE									+ 3.05					
DiPiero [43]	CIM	+ 1	+ 26□□	+ 9□□			+ 30□□	+ 17□□	+ 53□□						
Caruso [40]b	GAP	+ 19□□, NA, + 14□□		+ 9□□, + 3□□, + 6□□			+ 31□□, NA, + 32□□								
Vargas [36]	/													− 2.1%	Adj. UKPDS 10-year risk
Piatt [28]	PTPROV													+ 0.2	WHO-QWB10
Siminerio [22]	DSMT											+ 80,000 USD	Net revenue[f]		
Siminerio [21]	/	+ 20□□		+ 10□□ (LP)			+ 25□□	+ 35□□							
Bodenheimer [17]	CC						+ 58	+ 43							

dPACIC score: Patients Assessment of Chronic Illness Care (5 points in total).

a TC: total cholesterol; LP: lipid profile.

b This study included patients with T2 only, CVD only and T2 patients with CVD, so the data was listed in the same sequence.

c ACIC score: Assessment of Chronic Illness Care (11 points in total).

e Overall cost difference of illness care 2007-2003 per insured.

f DSMT reimbursement and educator salary.

□□ Significant difference ($P < 0.05$).

Table 4. Components of Chronic Care Model and limitations reported by the enrolled programs

Author (publish year)	Project name	CCM component						Limitations									
		HSHO	CIS	DS	DSD	SMS	CORP	Study design issue	Data contamination	Intervention issues	Patient issue	Professional provider issue	Data constraints	Measurement issue	Systematic bias	Follow-up issue	Money concern
Page (2015) [44]	FHQC	●	●		●	●	●	‡		‡	‡						
Ku (2015) [31]	FiLDCare	●	●	●	●	●	●							‡			
Frei (2014) [45]	CARAT	●	●	●	●	●									‡	‡	
Hariharan (2014) [20]	DITTO	●	●	●		●		‡			‡			‡	‡		
Mirzaei (2013) [42]	/		●	●	●	●					‡						
Turner (2012) [39]	/	●	●	●	●	●			‡	‡		‡					
Lalonde (2012) [41]	/	●	●			●	●							‡			
Musacchio (2011) [49]	SINERGIA	●	●	●	●	●								‡			‡
Chen (2010) [38]	Teamlet	●	●	●	●	●	●		‡	‡		‡				‡	
Barceló (2010) [18]	VIDA	●	●	●		●			‡		‡						‡
Yu (2010) [47]	SJOFMRP	●	●	●	●	●	●			‡							‡
Frølich (2010) [50]	/			●	●	●				‡				‡			
Khan (2010) [46]	/	●	●	●	●	●				‡			‡			‡	
Sunaert (2010) [51]	BE	●	●	●	●	●					‡		‡				
Stock (2010) [35]	GP	●		●	●	●	●	‡			‡				‡		
Sunaert (2009) [24]	BE	●	●	●	●	●				‡	‡	‡		‡		‡	‡
DiPiero (2008) [43]	CIM	●	●			●	●	‡	‡		‡		‡		‡		
Vargas (2007) [36]	/	●		●	●	●	●				‡	‡					‡
Caruso (2007) [40]	GAP		●	●	●	●		‡		‡							
Piatt (2006) [28]	PTPROV	●	●	●	●	●	●			‡			‡		‡		
Siminerio (2006) [22]	DSMT	●	●	●	●	●	●			‡				‡			‡
Siminerio (2005) [21]	/			●	●	●				‡							
Stroebel (2004) [37]	/		●	●	●	●	●	‡		‡	‡			‡			‡
MacLean (2004) [48]	VIDIS		●	●	●						‡		‡	‡			
Bodenheimer (2002) [17]	PHP			●	●	●											
	HPMG		●	●	●	●											
	CC		●		●	●											
Summary (total = 27)		18	22	23	23	26	11	6	4	12	11	4	5	9	5	4	7

dPACIC score: Patients Assessment of Chronic Illness Care (5 points in total).

a TC: total cholesterol; LP: lipid profile.

b This study included patients with T2 only, CVD only and T2 patients with CVD, so the data was listed in the same sequence.

c ACIC score: Assessment of Chronic Illness Care (11 points in total).

Figure 1. Search strategy for articles on Chronic Care Models

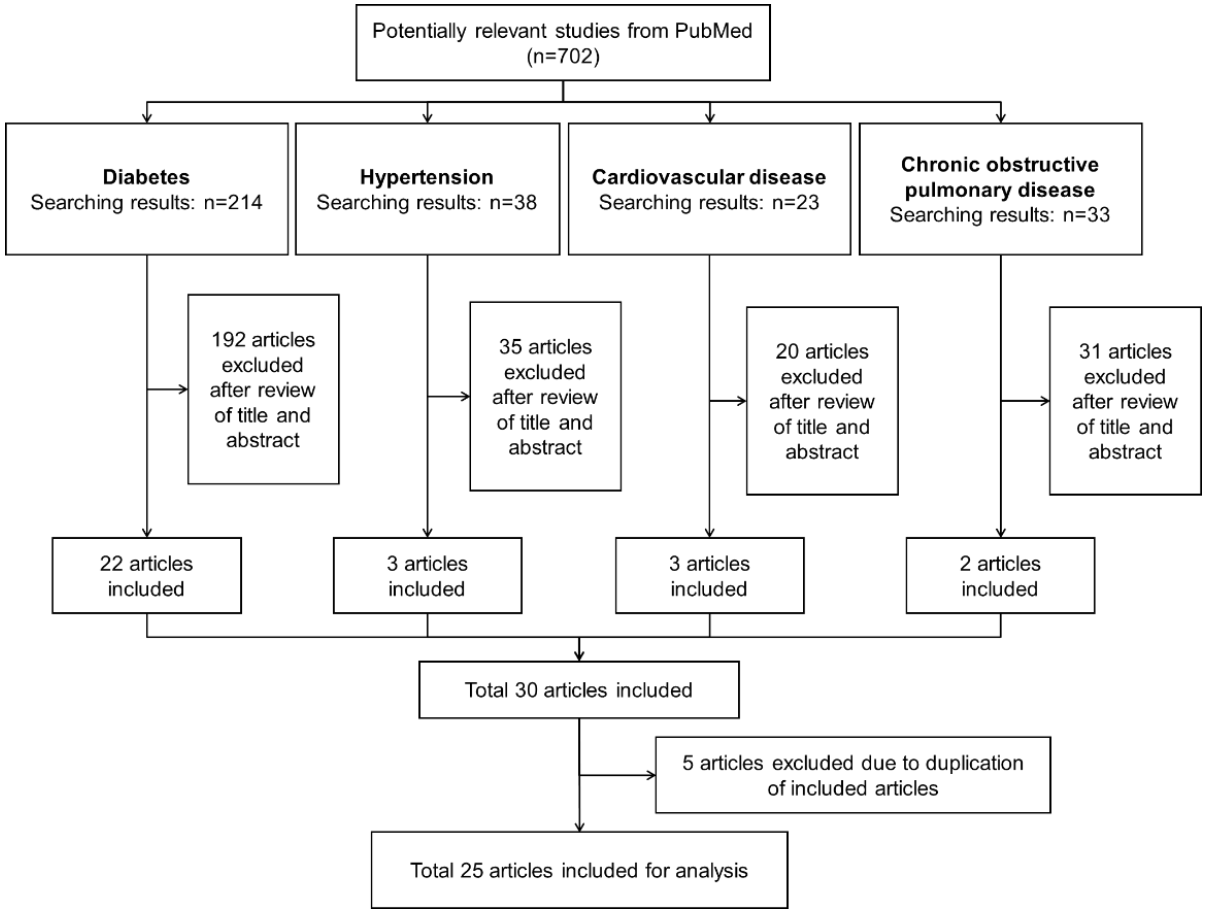

Figure 2. Benefits and limitations of implementing Chronic Care Models (CCM) in primary care